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DESIGNING ADAPTIVE CONTROL MANAGEMENT SYSTEM FOR SMALL WIND GENERATORS TO LOW POWER GRID

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Abstract: *The paper is focused on developing an adaptive control system for automatic connection of the small wind turbine to low power voltage network grid, used for community lighting. After programming relays, the testing part is focused on measuring and adjusting coupling influences, and protection cleaning faults influences. The experimental part is also dedicated to analysing the transient regine when the lighting system is switched from wind power generators to grid power system.*

Key words: *small wind turbine, grid connection, coupling influences, sofware- based fault cleaning*

1. INTRODUCTION

As far as PID control is a general-purpose automatic controller useful for controlling simple processes, since 70's year, it has significant limitations (amount of process knowledge versus process variation, and costs implementation).

Model Free Adaptive Control, as controlling approach has risen up as a technology that promises as a 'next-generation mainstream controller [1]

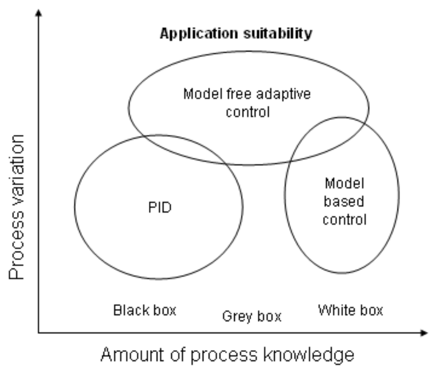

Fig.1. Application suitability from process validation point of view, correlated with the process knowledge

On the other hand, in industrial operations, a model-based adaptive control approach is hard to be implemented [2]. For dynamic modeling-based adaptive control, there may not be enough time and data to understand and to exercise a new model. For this reason, control engineers design a high-speed, complex control system with precise process models, which means significant financial support. Model-based control is fine approach for controlling a process where detailed knowledge is available ('White Box'- to control an airplane, since the mathematical models are readily available).

2. SMALL WIND TURBINE MODEL

In this idea, MFA is proper approach to control processes with qualitative process knowledge (figure 1), and there are not detailed process models (figure 2). Into this kind of process, the dynamics can have significant variations ('Grey Box'- we know the range of consuming energy for lighting, but there are some variations related with temperature [3]). A lot of industrial processes could be described by boxes when they have frequent load, fuel and dynamic changes.

MFA Control is an adaptive control method that does away with the tedious and time-consuming task of process modeling. This, in turn, means lower development costs and faster time to market for OEM suppliers, and lower operating costs and longer uptime for automation end-users.

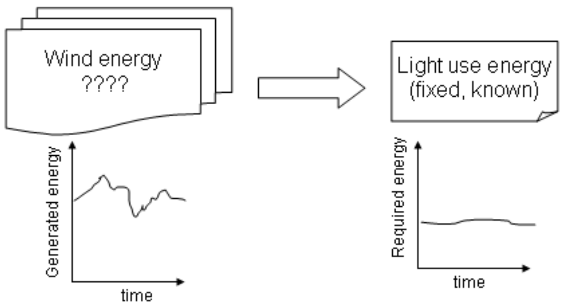

Fig.2. The amount of knowledge is different in the light use side then generation process side

3. IMPLEMENTATION WIND TURBINE MODEL

By analyzing MFA technology-based in figure 2, we can assume that precise quantitative knowledge of the process is not necessary (on the right side of the process); we assume that the process identification mechanisms or identifiers are not included in the system (on the left side of the process); we assume that the controller design for a specific process is not needed (right side); we assume that the manual tuning of controller parameters is not required (right side); and we assume that the closed-loop system stability analysis and criteria are available to guarantee system stability, by designing the small wind generator in accordance with the local wind parameters (left side of the process).

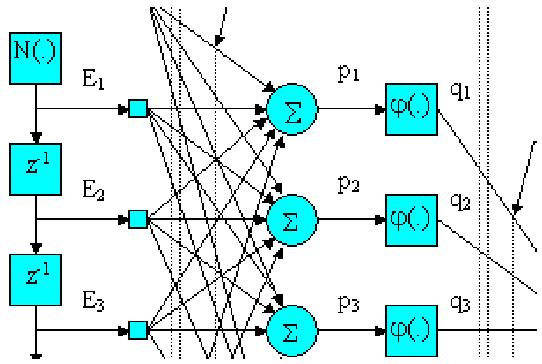

Fig.3. Part of basic architecture of MFA control model [4], where the amount of knowledge is different represented

In accordance with the model we add control inputs E1, E2…En to p1, p2…pn time- based stages, in order to obtain desired parameters as q1, q2…qn (left side of the process- figure 2). For fine adjustment we add τ1, τ2…τn correction inputs correlated with lighting system (energy demand, environment related parameters).

In our implementation, the hazards scenario created during islanded operation are: unearthed operation of the distribution system; lower fault levels; out of synchronization reclosure; voltage levels outside statutory limits; reduction in quality of supply; risk to maintenance personnel.

For our application (Fig.4), we use a suc system that is capable to react also to fault conditions, such: under frequency (one level delayed); over voltage (one level delayed, one level instantaneously; under voltage (one level delayed); loss of mains (instantaneously); high overcurrents (short circuit); thermal overload; earth fault; neutral voltage displacement

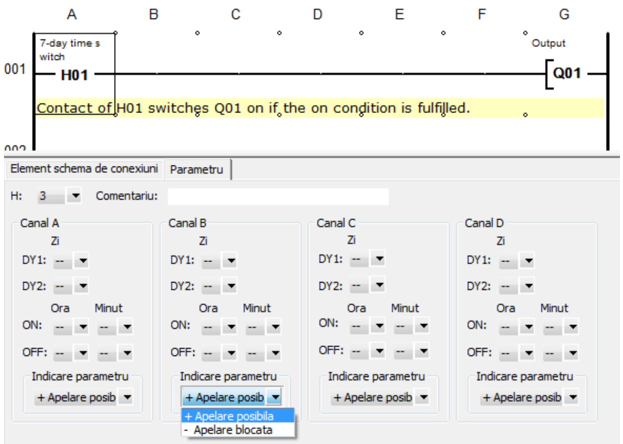

Fig.4. Line sequence for codding Easy 500 Relay in order to fulfil main program requirements

The program constists of routine for: time delay, normal swithing, values comparator, counters, master control.

4. TESTS AND RESULTS

A time delay to voltage establishment is usually allowed for the operation of voltage and frequency protection. This time delay is to minimize nuisance tripping due to grid system disturbances. The maximum time delay must be less than the minimum operating time of auto-reclose devices used on the distribution line. Typical maximum time delay for lighting systems is 15 sec – this includes the operation time of any relays and breakers in the control and protection system. Generator operators should make use of this time delay to minimize nuisance tripping (Fig.5).

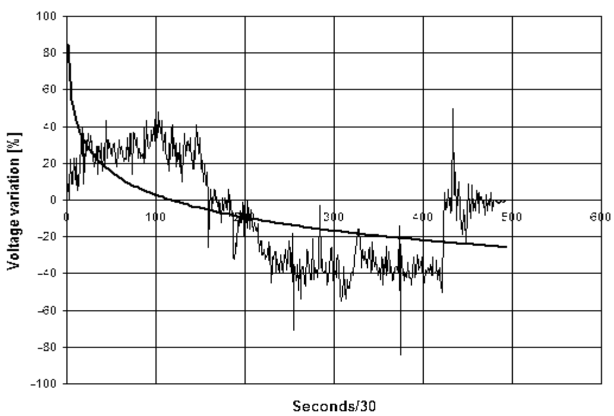

Fig.5. Recorded time delay minimize nuisance tripping due to grid system disturbances

This kind of test- records have to be conducted also in the case of fault conditions.

5. CONCLUSION

By the measurement, zero voltage for about 150 ms at the grid connection point. For that matter, the total duration of the low voltage period referred in the Grid Code is 1.5 s. On the other hand, Short-Term Interruption is introduced and always required when low voltage occurs for less than 1.5s and the Fault Ride Through (FRT) should not take place without tripping [7].

The wind turbines must ensure that the power generation after FRT continues within the shortest possible time. To achieve this, the required minimum power gradients must be previously defined.

Facilities that use power electronics must remain operational throughout the entire voltage range except for voltage levels greater than 1.25 p.u. where temporary blocking is allowed and must deblock as soon as the voltage goes under 1.25 p.u.

By running connection process through intelligent relay, a secure, reliable, and cheap implementation is developed.

The modern electricity supply network is a complex system. The somewhat vague term “power quality” is used to describe the interaction between traditional producers operating fossil fired, nuclear, or hydro power plants and consumers. The latter may be large (heavy industry - metal melting) or small (private homes) consumers.

6. REFERENCES

VanDoren, V., (2001), *Model Free Adaptive Control—New Technique for Adaptive Control Addresses a Variety of Technical Challenges*, Control Engineering Europe, March 2001.

Liptak, B., (2005), *Instrument Engineers' Handbook - Process Control and Optimization*, (Section 2.15, MFA Control by George Cheng). CRC Press LLC, October 2005.

*** Light standard characteristics, http://www.toshiba-lighting.com/servlet/ShowInfoSR?M=S97SFR11RFK1KFL1LF, *Accessed on: 2010-04-13*

Chihaya A., Marc A. B. & Mark E. T. (2001) , *Structural, mechanical thermodynamic, and optical properties of condensed matter* (PACS 61-68, 78) J. Appl. Phys. 90, 5048; doi:10.1063/1.1409582 (4 pages),

*** Model-Free Adaptive Control: Impact on the Automation Industry,http://www.controlengeurope.com/article.aspx?ArticleID=31005, *Accessed on: 2010-05-22*

Fuentes, J., Ca˜nas, A. M. & Molina, International Review of Grid Connection Requirements related with Voltage Dips for Wind Farms, http://www.icrepq.com/icrepq07/330-fuentes.pdf, *Accessed on: 2010-05-25*

Erlich, I., Winter, W. & Dittrich, A., (2006), *Advanced grid requirements for the integration of wind turbines into the german transmission system*, Power Engineering Society General Meeting IEEE, Montreal (QC Canada), June, pp. 7–10.

Kalicki, A.; Makowski, L. & Michalski, A. (2008). *Distributed measurements Systems, - A web System Approach*, pp. 44-50, IEEE Instrumentation measurement, Vol.11, No.6, December 2008

Chisnell, D. (2010). *Usability Testing: Taking the Experience into Account*, pp. 13-15, IEEE Instrumentation measurement, Vol.13, No.2, December 2010